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Channel dynamics of a riffle-pool floodplain river under disturbed and undisturbed sediment load conditions (Mulde river, Germany)

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The Mulde river, a meandering floodplain river in Germany (w = 40-65 m, MQ = 64 m3s-1 , I = 0.018-0.029 %, bed material generally coarse sand and fine gravel to coarse gravel) has experienced comparably limited human interference along large reaches. However, close to the Bitterfeld lignite mining area an artificial lake came into existence (Mulde reservoir) in 1975 when an abandoned open-cast mining pit was flooded by an unreversed diversion of the river creating a disturbed downstream reach that is hydrologically comparable to the undisturbed one but hydraulically different. Water retention by the reservoir is negligible and floods are transmitted without considerable delay but sediment retention is considered 100% for bedload and estimated 80% for the entire solid load.

The results presented in this contribution are based on first systematic investigations of the river channel and focus on channel dynamics taking into account flood and adapation related bed morphology, bedload transport, and associated bank activity. Hydrographic surveys were performed during sequences of different stages, low stage geodetic surveys were evaluated, bed material samples were taken, and bank activity was mapped. A realtime-DGPS based hydrographic survey system proved perfectly suitable for field surveys.

In both the disturbed and the undisturbed reach, well-developed immobile riffle-pool sequences of 400-600 m length were found. There have been indications for the development of superimposed dunes at stages close to bankfull which were not followed up in this study.

At any stage, the upstream channel is shallower than the downstream one in terms

of mean and minimum water depths. Frequency distribution of depths are broader and flatter downstream, shifted and extended towards the deeps (pools). Downcutting thus is considered to be confirmed. Bed form amplitudes are greater and flood-related variability is less under disturbed downstream than under undisturbed conditions. Upstream flood stage amplitudes approach those downstream but remain less during the entire course of floods. Highest bed form amplitudes during floods may occur with delay of days after peak discharges which casts light on control factors other than flow velocity and shear stress. Downstream bed morphology is considered as relic flood morphology being preserved during low stages due to the lack of bed load. This is corroborated by the shapes of depth frequency distributions.

Generally, increase of bed form amplitudes is considered to be associated with bed mobility that moves the load regardless of bed stretches sloping contrary to river gradient (riffle stoss slopes around 0.6-1.2%). Riffles are aggraded and pools degraded during this phase. Decrease of amplitudes occurs during subsequent low discharges. Bed mobility then is restricted to bed stretches sloping according to river gradient. This disconnected type of bed mobility reduces bed amplitudes only to a limited extent.

Contrary to expectations, bank activity downstream in terms of length of failed bank stretches even seems to be less than upstream. Evidence for a change of channel width is to weak to be significant and there is no bottom armouring downstream but symmetry of cross sections is clearly greater. It is hypothesized that the downstream channel has adapted equilibrium conditions by adjustment of the parameters channel form and slope, and form roughness.

A velocity reversal in terms of average flow velocities was observed at the upstream reach at $Q > 130$ m3s-1 (40% Q/Qbf). No reversal but velocity equalization was observed at the downstream reach with observations limited to stages below Q/Qbf $<$ 70% still leaving open, whether a reversal occurs at higher stages. Nevertheless, bed mobility downstream occurs before velocity equalization. This implies that a velocity reversal of average flow velocities is not causative for the maintenance of riffle-pool-sequences at the lower reach.